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| **Grade 11 Chemistry, Academic (SCH3U) Solutions and Solubility: “Magic water demonstration”** |  |
| **Minds On – 3 minutes** | **Connections** |
| **Whole class ⇒ Review on solubility and polarity**   * Definitions and class discussion about what solubility, polarity is * Discuss why ionic compounds are able to dissolve in water | AfL: review on what they already know and find out if they are comfortable with these terms before moving on |
| **Action – 7 minutes** |  |
| **Whole class ⇒ demonstration and explanation**   * Water 🡪 wine 🡪 milk 🡪 beer DEMO (2 minutes) * Explain what is going on in each beaker with respect to solubility, polarity and electronegativity (5 minutes) * Beaker 1: ionic dissociation in water * Beaker 2: indicators 🡪 phenolphthalein detects the OH ions turning it pink * Beaker 3: ionic dissociation of BaCl in water and stronger attraction between Ba and CO3 ions versus the polar water * Beaker 4:HCl added and charge increases, which breaks apart the BaCO3 and **ALSO** rips off an O off the CO3 leaving CO2 (bubbles). The bromthymol blue is an indicator which detects the H and turns it a brownish/yellow |  |
| **Consolidation and Connection – 2 minutes** |  |
| * Why is polarity of water important in or everyday lives? E.g. water and oil |  |

**Related to Curriculum:**

This demonstration can be used to teach a variety of topics found within chemistry such as:

* Solutions and solubility
* Acids and bases
* Chemical reactions
* Polarity and electronegativity

I am using this demonstration as a tool to teach about polarity of various compounds and acids and bases. I would have expected the students to have prior knowledge about:

* Polarity
* Electronegativity
* Ionic compounds
* Polar, covalent and non-polar compounds

This could be a good demonstration to use to wrap up polarity and introduce acids and bases and indicators.

**Ministry Expectations:**

**E2.5** write balanced net ionic equations to represent precipitation and neutralization reactions

**E3.1** describe the properties of water (e.g., polarity, hydrogen bonding), and explain why these properties make water such a good solvent

**E3.2** explain the process of formation for solutions that are produced by dissolving ionic and molecular compounds (e.g., salt, oxygen) in water, and for solutions that are produced by dissolving non-polar solutes in non-polar solvents (e.g., grease in vegetable oil)

**Teacher Chalkboard Notes:**

Na2CO3 + H2O 🡪 2Na+ + CO32- + H+ + OH – (ion equation)

2Na+ + CO32- + H+ + OH – 🡪 **2Na+ + HCO3─ + OH –**

Beaker 1:

Beaker 2:

Phenolphthalein indicator detects the OH ions and turns pink

Beaker 3:

2Na+ + HCO3─ + OH – + BaCl2 🡪 2Na+ + CO32- + H+ + OH –+ Ba2+ + 2Cl – (ion equation)

2Na+ + CO32- + H+ + OH –+ Ba2+ + 2Cl – 🡪 **2Na+ + BaCO3+ H2O + 2Cl** –

Beaker 4:

2Na+ + BaCO3+ H2O + 2Cl –+ 2HCl 🡪 2Na+ + BaCO3 (s)+ 4Cl – + 2H+ + H2O (ion equation)

2Na+ + BaCO3 (s)+ 4Cl – + 2H+ + H2O 🡪 2Na+ + Ba2+ + CO32- + 4Cl – + 2H+ + H2O

2Na+ + Ba2+ + CO32- + 4Cl – + 2H+ + H2O 🡪 **2Na+ + Ba2+ + CO2 (g)+ 2H2O + 4Cl –**

Beaker 1:

When the ionic substance Na2CO3 is placed in an aqueous solution, the attractive interactions with the water molecules overcome the ionic attractions and the ions separate in solution.

The OH- ions create a basic solution, so when we pour it into the wine glass containing phenolphthalein, the indicator detects this basicity and turns the solution pink.

Beaker 3:

When the solution is added to BaCl2, the two Cl- ions dissociate immediately into water leaving Ba2+ available to interact with the ions in the solution. HCO3- decides it would be better off (more stable because of equal charge) with the Ba2+ and frees itself up to bond by releasing the H+ back into solution. H+ is gladly taken back by OH- and the solution returns to neutral and the pink wine colour is gone.

Notice that the BaCO3 molecule has no interaction with the water molecules around it. This is because the attractive force between the Ba2+ and CO32- ions is much greater than the attractive interactions of the polar water molecules. This results in solid BaCO3 particles being suspended in the mixture – accounting for the milky white appearance (remember it is the attractive interactions of the polar water molecule that allows an ionic substance to dissolve in water).

Beaker 4:

When the solution is added to HCl, the H+ and Cl- ions dissociate and the H+ ions cluster around the solid BaCO3. Not only is the increased charge enough to overcome the attractive force between the Ba2+ and CO32- ions, but it is enough to rip an O2- ion off the CO32-, leaving the stable CO2 which escapes solution as a gas.

The H+ ions create an acidic solution and are detected by the bromothymol blue indicator, which turns the solution yellow.

**Effects of polarity on solubility:**

**Review (3 mins):**

Lets start with a review of what solubility and polarity is:

Solubility 🡪 the property of a solid, liquid or gas (solute) to dissolve into a solvent to form a homogeneous solution

* many factors affect the solubility of a substance such as temperature and pressure
* polarity is another factor that can affect solubility
  + does anyone know why polarity would affect whether or not it dissolves into a substance?
    - a substance usually dissolves in something hat has a similar structure to itself “like dissolves like”

Polarity 🡪 results from the unequal distribution of charges of atoms within a compound

* what is the number one most important compound we always talk about when we discuss polarity?
  + Water
* Why is water so important?
  + It has a positive end and a negative end
* What component of a compound do we look at to determine whether or not it is polar?
  + Electronegativites

Remember that ionic compounds are easily dissolved in polar solvents due to the weak binds between the two ions. Do you think an ionic substance will readily be dissolved in water? Why?

* yes because water being polar and having a positive and a negative end allows it to pull apart the ions found in the salt

**Perform demo (2 mins)**

**Taking up demo (5 mins):**

Na2CO3 + H2O 🡪 2Na+ + CO32- + H+ + OH – (ion equation)

2Na+ + CO32- + H+ + OH – 🡪 **2Na+ + HCO3─ + OH –**

**Beaker 1:**

The ionic compound Na2CO3 is dissociated in the water and because water is a polar molecule these ions split. Hydrogen then binds onto the carbonate ion leaving a pool of OH ions

**Beaker 2:** since there is just phenolphthalein in the beaker and there was a pool of OH ions in the last beaker, when it was poured in it turned pink because phenolphthalein is an indicator.

**Beaker 3:**

2Na+ + HCO3─ + OH – + BaCl2 🡪 2Na+ + CO32- + H+ + OH –+ Ba2+ + 2Cl – (ion equation)

2Na+ + CO32- + H+ + OH –+ Ba2+ + 2Cl – 🡪 **2Na+ + BaCO3+ H2O + 2Cl** –

The ionic compound BaCl immediately dissociates in the water when the solution is added, leaving free Ba ions to react with the HCO3 ions since it is more stable. So HCO3 looses one H which bonds with the free OH to make water which is why the pink colour disappears. **Notice** that the BaCO3 does not get dissociated in the water because the attractive forces between those two ions is greater than the attractive forces of the polar water molecule. This is the reason why the solution turns a white milky opaque colour is because the BaCO3 is solidified throughout the solution

**Beaker 4:**

2Na+ + BaCO3+ H2O + 2Cl –+ 2HCl 🡪 2Na+ + BaCO3 (s)+ 4Cl – + 2H+ + H2O (ion equation)

2Na+ + BaCO3 (s)+ 4Cl – + 2H+ + H2O 🡪 2Na+ + Ba2+ + CO32- + 4Cl – + 2H+ + H2O

2Na+ + Ba2+ + CO32- + 4Cl – + 2H+ + H2O 🡪 **2Na+ + Ba2+ + CO2 (g)+ 2H2O + 4Cl –**

When the solution is added to the HCl the HCL dissociates into H and Cl. The H ions cluster around the BaCO3. The H ions increase the charge, which is strong enough to dissociate the Ba, and CO3 and it is also so strong that it rips off an O from CO3 leaving CO2 and this is why we see bubbles. Bromthymol blue is another indicator used in this demonstration that detects H ions and changes colour in the presence of H to a yellowish/brown colour.

**Application: Polarity of water in everyday situations:**

Water and oil 🡪 as most of you have discovered this before, you may notice that water and oil do not mix together. This is due to the structure and polarity of the water and the oil:

* water is polar so it is positive on one end and negative on the other
* oil is non-polar because the charges are evenly distributed throughout the molecule
* think of water as like a magnet with opposite sides but oil as a non-magnet so they do not attract each other
* when you get mud on you hands, you can wash it off with water because mud consists of water and “like dissolves in like” but oil cannot be dissolved into water so water cannot simply wash oil away.

**“Magic Water” Demo**

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**INTRODUCTION:**

This demonstration shows the chemical change of substances when they are mixed with one another. The “water” in the first beaker changes into “wine” which changes into “milk” and then “beer”. The “water” at the beginning of the experiment is actually sodium bicarbonate and sodium carbonate solution, which is mixed with other substances, having a changing effect on their physical properties.

**MATERIALS:**

250mL beaker

250mL beaker

250mL beaker

250mL beaker

4 drops bromothymol blue indicator

5 mL concentrated HCl (just before starting demo)

10mL of saturated barium chloride solution

a few drops of phenolphthalein indicator

¾ full with water; 25 mL saturated sodium bicarbonate and 20% sodium carbonate solution (pH 9)

**Safety precautions:** Wear gloves since hydrochloric acid is concentrated and can burn through skin. Also wear goggles at all times.

**Disposal:** while wearing gloves and goggles, the contents of the last beaker can be poured down the sink with lots of water.

**PROCEDURE:**

1. Obtain four 250ml beakers.
2. In the “water” beaker, fill the beaker about ¾ full with distilled water and add 20-25mL of saturated sodium bicarbonate with 20% sodium carbonate solution (pH 9)
3. In the “ wine” beaker, place about 5 drops of phenolphthalein indicator into the beaker
4. In the “milk” beaker, pour about 10mL of saturated barium chloride solution into the beaker
5. In the “beer” beaker, place a few sodium dichromate crystals or bromthymol blue
6. Before performing the demonstration, add about 5mL of concentrated Hydrochloric acid into the beer beaker
7. Simply pour the contents of the first beaker into the second beaker. Then pour the second beaker into the third and then pour the contents of the third beaker into the fourth.

**DISUCSSION:**

The first beaker contains water and sodium carbonate solution. The carbonate ions cause the solution to be a weak base that produces OH- ions (CO32-HCO3- + OH-). The second beaker contains phenolphthalein indicator which is colourless by itself but changes colour to pink in the presence of an alkaline so when the “water” is poured into the beaker it changes (HIn + OH-In- + H2O). The third beaker contains saturated barium chloride. The barium ions mix with the carbonate ions to produce barium carbonate, which is a white solid precipitate (Ba2+ + CO32-BaCO3(s)). The last beaker contains concentrated HCl. The barium carbonate reacts with the HCl to produce barium ions, water and carbon dioxide gas bubbles. The bromthymol blue is yellowish-brown in acidic solution making it look like beer (BaCO3(s) + 2H+Ba2+ + H2O + CO2(g)).

**RERFERENCES:** Woodhall, G. (n.d.). *Cheers! - turn water into wine, milk, and beer.*. Retrieved from http://educ.queensu.ca/~science/main/concept/gen/g09/N Puksa/Chemistry Website/Water to Wine to Milk to Beer.html

**“Magic Water” Demo**

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**Beaker 1**:

Na2CO3 + H2O 🡪 2Na+ + CO32- + H+ + OH – (ion equation)

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**Beaker 3:**

2Na+ + HCO3─ + OH – + BaCl2 🡪 2Na+ + CO32- + H+ + OH –+ Ba2+ + 2Cl – (ion equation)

2Na+ + CO32- + H+ + OH –+ Ba2+ + 2Cl – 🡪 **2Na+ + BaCO3+ H2O + 2Cl** –

**Beaker 4:**

2Na+ + BaCO3+ H2O + 2Cl –+ 2HCl 🡪 2Na+ + BaCO3 (s)+ 4Cl – + 2H+ + H2O (ion equation)

2Na+ + BaCO3 (s)+ 4Cl – + 2H+ + H2O 🡪 2Na+ + Ba2+ + CO32- + 4Cl – + 2H+ + H2O

2Na+ + Ba2+ + CO32- + 4Cl – + 2H+ + H2O 🡪 **2Na+ + Ba2+ + CO2 (g)+ 2H2O + 4Cl –**

1. Using the equations given above, explain what is happening in each beaker
2. What is an indicator?
3. Why does the indicator turn the solution into a wine colour?
4. What does it mean to be “polar”? Why is water polar?
5. Do you think that a non-polar molecule would dissolve in water? Why or why not?

******“Magic Water” Demo**

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1. Using the equations given above, explain what is happening in each beaker

**Beaker 1:** Na2CO3 gets dissociated in the water leaving OH- ions

**Beaker 2:** Since there was phenolphthalein indicator at the bottom, it detects the OH- ions and turns pink

**Beaker 3:** The BaCl dissociates and the Ba and CO32- ions join together because of the strong attraction, which forms the milky opaque chalky-like substance. The solution is not longer pink due to the water

**Beaker 4:** The addition of the H+ ions makes the charge greater, causing the BaCO3 to dissociate and the charge is so strong that one of the O gets ripped off the CO3 leaving CO2 gas, hence the bubbles. The solution turns to yellow because of the H+ ions and the bromthymol indicator

1. What is an indicator?

An indicator is a chemical detector, which detects protons in solution and indicates whether something is, and acid or a base based on a colour change.

1. Why does the indicator turn the solution into a wine colour?

When the sodium carbonate is in the presence of the water, hydroxide ions are produced making it a basic solution. Since the second beaker contains phenolphthalein indicator, the solution changes to a pink colour since the indicator is pink in alkaline solutions.

1. What does it mean to be “polar”? Why is water polar?

Polar 🡪 differences in electronegativity of the atoms in a compound and the asymmetry of the compound’s structure

Water is polar because of the unequal sharing of electrons between oxygen and hydrogen.

1. Do you think that a non-polar molecule would dissolve in water? Why or why not?

No. Water is polar and can only dissolve polar or ionic compounds. Non-polar molecules cannot be dissolved into polar molecules because their charges are neutral.